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PROCESSING OF COAL AND PRODUCT THEREOF

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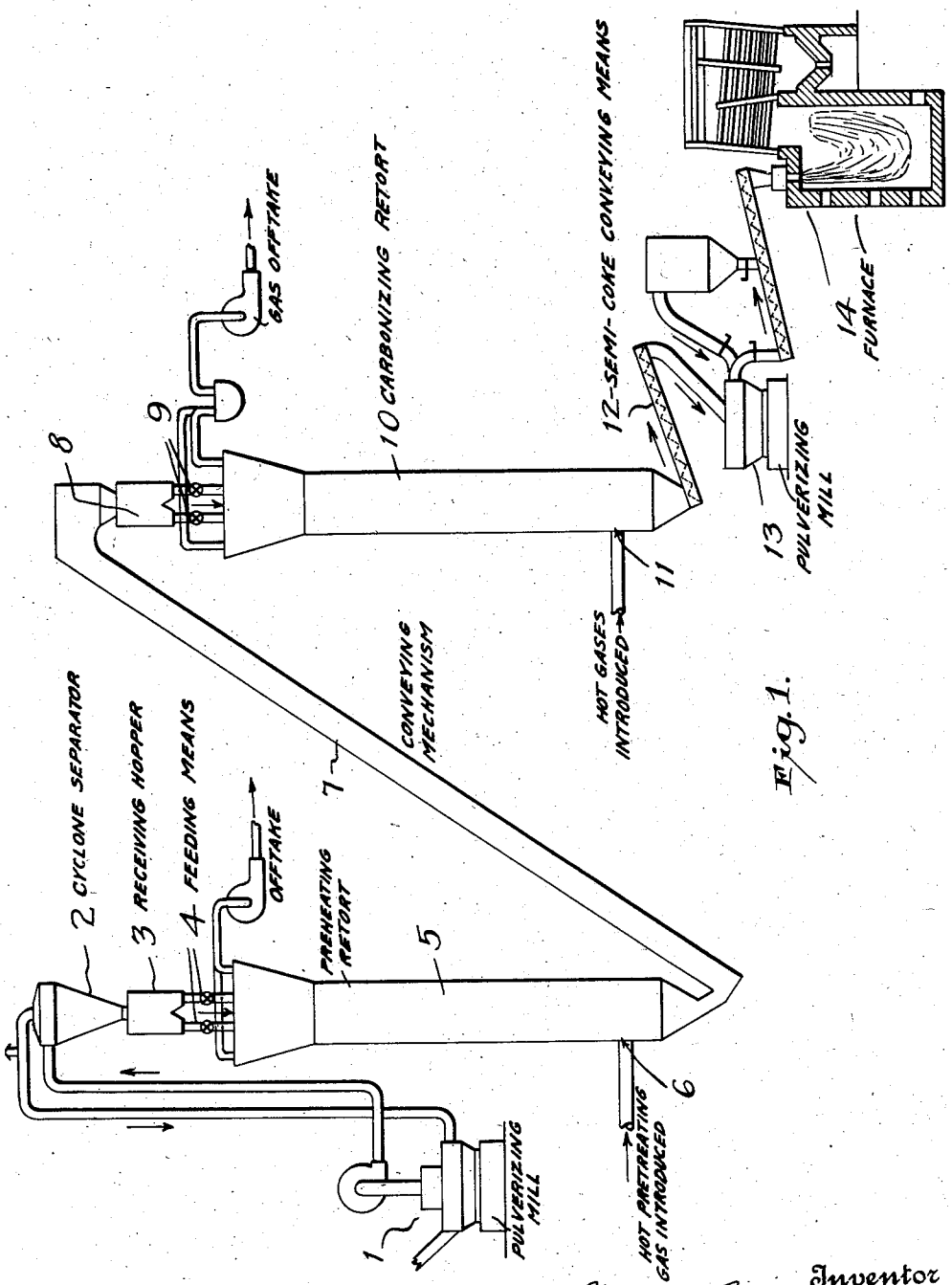


Fig. 1.

Inventor
Walter Runge and
Edwin A Packard
By Their Attorney
Edwin A Packard.

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Fig. 2.



Fig. 3.



Fig. 4.



Fig. 5.



Inventors

Walter Runge and

Edwin A. Lehmann

By their Attorney

Edwin A. Lehmann.

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UNITED STATES PATENT OFFICE

WALTER RUNGE, OF EAST ORANGE, NEW JERSEY, AND EDWIN A. PACKARD, OF YONKERS, NEW YORK, ASSIGNORS, BY MESNE ASSIGNMENTS, TO INTERNATIONAL COAL CARBONIZATION COMPANY, A CORPORATION OF DELAWARE

PROCESSING OF COAL AND PRODUCT THEREOF

Application filed June 12, 1925. Serial No. 36,590.

The invention relates to the processing of coal. It is particularly directed to the converting of coal into a form whereby it is readily attacked by oxygen thus facilitating rapid and high temperature combustion. One advantage of the invention is that it facilitates and furthers the employment of a relatively small combustion chamber although the invention is not limited to the use of the fuel in a relatively small combustion chamber since the fuel is advantageously employed in any present day furnace construction having suitable instrumentalities for feeding fuel thereto and for bringing the combustion supporting air to the fuel in any suitable manner.

According to one aspect of the invention finely divided coal is heat pretreated under conditions to drive off only a small portion of its hydrocarbon volatile contents—leaving substantially all of the hydrocarbon volatile contents in the pretreated residue—and under conditions to slightly increase the size of the coal particles. Thereafter the pretreated residues are subjected to low temperature carbonization under conditions to convert many of the coal particles into relatively hollow spheroids many of which have what appears to be one or more windows—visible under the microscope. The product or semi-coke thus obtained is thereafter crushed—or further pulverized—so as to break up the cell-like structures or spheroids in order to materially increase the surface area of the residue. Thereafter the treated residue is burned in any suitable manner, preferably by burning the crushed residue in suspension in any suitably constructed pulverized burning fuel furnace, for example, a boiler furnace.

The invention has various aspects as hereafter will be apparent from that which follows, and according to the broader aspects of the invention the pretreating prior to low temperature carbonization need not be employed.

In order that the invention as to its fundamentals may be readily understood, a specific mode of its realization will now be described, this in reference to the accompanying drawings which constitute a part of this specification and in which drawings—

Figure 1 diagrammatically illustrates a plant comprising an arrangement of coal processing apparatus in association with a boiler furnace wherein there is burned the crushed semi-coke or pulverized product which is produced in accordance with the invention.

Figure 2 is a reproduction of a micro-photograph of a particle of raw pulverized coal under a magnification of approximately 155 diameters and shows the angular nature of the particles or minute fragment of coal. In other words, it will be noted that the coal fragment is delineated in many respects by sharp lines and sharp edges.

Figure 3 is a reproduction of a micro-photo-graph showing the appearance of a minute fragment of coal after heat pretreatment in a gaseous medium at approximately 650 degrees F. This reproduction of the micro-photo-graph was made under a magnification of 155 diameters. Here it will be noted that the edges of the fragment have become rounded due presumably to fusion and the fragment is solid and opaque. The general shape is spherical. This is illustrative of the appearance of the minute fragments of coal after a hot gas pretreatment at the approximate temperature just specified.

Figure 4 is a reproduction of a micro-photo-graph illustrative of a relatively hollow spheroid having a shell-like structure with windows in the shell-like structure. This is a particle of the product after the low temperature carbonization during which carbonization the average temperatures approximated 1000 degrees F. This figure is a reproduction of a micro-photo-graph taken under a magnification of 155 diameters.

Figure 5 shows some fragments of semi-coke and is illustrative of the product obtained as by crushing of the semi-coke product illustrated in Figure 4. The crushed semi-coke of which the fragments of this figure are illustrative, is sometimes referred to as the crushed semi-coke of the process or as the pulverized product because it has

been subjected to the crushing or pulverizing action of a mill subsequent to its production by the low temperature carbonization outlined.

Figures 2 to 5 inclusive illustrate step by step the processing of the coal in the instrumentalities associatingly arranged according to Figure 1 prior to the burning of the crushed product (illustrated in Figure 5) in the boiler furnace indicated in Figure 1. There has been incorporated in the patent file as originally presented in the United States Patent Office, a set of micro-photo-graphs duly labeled and which illustrates in refined detail actual structures realized from the performing of the invention prior to filing an application for patent in the United States Patent Office.

Figure 5 is merely illustrative as to the shape and definition of the particles which may be obtained by the crushing operation. The parts in Figure 5 have not been taken from actual specimens or in other words are not reproductions of micro-photo-graphs of specimens. The pieces of Figure 5 are intended to illustrate how these small coke particles might be broken down by crushing in order to form greater air attacking surfaces than would be the case if the particles from which they were made were not crushed, all of this having in mind the art of combustion when these broken up particles are subjected to burning. The pieces of Figure 5 are manifestly at a much enlarged scale.

The invention in this case primarily revolves about the deliberate processing of finely divided coal so as to produce semi-coke in finely divided form, the deliberate breaking up of this small coke into much smaller particles or fragments and the deliberate burning of these small particles so as to take advantage of the results of the series of steps previously defined.

Referring now to the drawings in detail 1 indicates a pulverizing mill wherein the coal to be processed is initially pulverized to the desired degree of fineness for example to a fineness such that approximately 60% will pass through a 200 mesh screen (a screen defined by wires crossing at right angles to each other so as to form forty thousand openings per square inch) and so that substantially all of the pulverized coal will pass through a 40 mesh screen.

The pulverized coal is pneumatically conveyed to a cyclone separator 2 where it is collected and from which it is conveyed to a receiving hopper 3 from which it is fed by a suitable means 4 into the top of a pretreating retort 5. Within this pretreating retort the pulverized coal in cloud-like formation moves downwardly with delayed gravitation into and counter to slowly rising hot pretreating gases which are introduced in the lower regions of the retort as at 6. These pretreating gases are preferably, although not necessarily, heated air. When air is thus employed it constitutes a hot oxidizing medium by which the oxygen content of the coal undergoing pretreatment is slightly increased. The pretreated pulverized coal ultimately settles at the bottom of the pretreating retort and is collected and passed by any suitable conveying mechanism as 7 into a receiving hopper 8 from which it is fed by any suitable means as 9 into the top of a carbonizing retort 10. Herein the pretreated pulverized coal settles in cloud-like formation and with retarded gravitation into and counter to slowly rising hot carbonizing gases which serve to reduce the coal into semi-coke.

The pretreating and carbonizing processes, the various temperatures employed and their definition, the length of time the coal is treated in the different steps, and the apparatus therefor is described in detail in Patent No. 1,669,023, granted May 8, 1928, to Walter Runge, one of the applicants herein. On page 3 of this Patent No. 1,669,023 is disclosed an example of the pretreating process, wherein the hot oxidizing gas, or air, is admitted to the retort at a temperature of approximately 800 degrees F. and leaves the upper portion of the retort at approximately 500 degrees F., the coal being subjected to the action of the hot air for approximately thirty seconds, during which time all of the moisture and only a small portion of the hydrocarbon volatile content of the coal is removed. The fine coal particles are also slightly enlarged in size. It will be understood, of course, that the above process will be modified to secure the desired results, depending on the character of the coal treated, length of the retort, etc.

On page 4 of this Patent No. 1,669,023 is disclosed an example of the method of carbonizing the pretreated coal, wherein it is stated that the gases used in the carbonizing process are substantially chemically inert with respect to the coal undergoing carbonization.

The hot gases for effecting the carbonization within the carbonizing retort 10 are supplied at the bottom thereof as at 11 and the temperatures of these rising hot gases average approximately 1000 degrees F. The settling or gravitating of the coal undergoing the carbonizing operation is sufficiently delayed by the upwardly moving hot gases to effect the desired degree of carbonization or in other words, a sufficient length of time to substantially reduce the hydrocarbon volatile content of the coal and also a sufficient length of time to reduce the oxygen content of the coal below that which the original coal possessed.

It will be manifest that in the plant for realizing the invention suitable pipings and

other instrumentalities should be employed for withdrawing and disposing of the pretreated gases and for collecting, purifying, storing or otherwise handling of the gases employed in or given off by the carbonization.

As to the effect of the different steps upon the coal undergoing treatment, this is illustrated by Figures 2 to 5 inclusive. All the coal undergoing treatment is in relatively finely divided form being in the form of minute fragments or particles and a typifying illustration of a fragment of raw pulverized coal is seen in Figure 2. Here it will be noted that the prominent characteristics are the sharp lines and edges.

When the pulverized coal undergoes the hot pretreatment to wit under conditions such that the average temperatures of the pretreating gases approximate 650 degrees F. it loses these sharp edges and they are replaced by relatively smooth rounded surfaces. Where the pretreating gases are hot oxidizing gases then the pretreated particles of pulverized coal take on, as determined by chemical analysis, another characteristic in that they have been oxidized by the hot pretreating air so that for example, pulverized coal having an initial oxygen content of 7½% may after the pretreatment, have an oxygen content of 8½%. The coal which has been thus pretreated and after having been subjected to the above mentioned low temperature carbonization, for example at temperatures averaging approximately 1000 degrees F., and according to the process herein described becomes further changed as to its physical and structural characteristics as is clearly illustrated in Figure 4.

A study of the product resulting from the low temperature carbonization shows that it is semi-coke compound mainly of spheroids, as shown in Figure 4, most of which are relatively hollow and many of which have the appearance of windows in the surface thereof, which windows are not apparent to the naked eye but with the aid of transmitted light are visible under the microscope.

It may not be desirable in all instances to subject the pulverized coal to a heat pretreatment prior to the carbonization. Here again the product which has been produced according to one aspect of the process is a semi-coke composed in main of spheroids which are relatively hollow and many of which have windows. With the direct low temperature carbonization however, the particles are, as a general rule, slightly larger than in the instance where the particles are produced by the pretreatment which is followed by the low temperature carbonization. This is best discernible by comparative screen analysis of the raw pulverized coal, the product realized by the direct carbonization, and the product derivable by the dual process to wit the pretreating process which is followed by the low temperature carbonization.

According to the process of this application one can take coal having a hydrocarbon volatile content of, for example 34%, and an oxygen content of approximately 7% to 10% and readily obtain therefrom the desired resulting semi-coke product. When a pretreatment is employed (although according to the broader aspects of the invention the pretreating or preheating is not necessarily employed) the steps of a specific aspect of the invention would include the following: pulverizing the raw coal to a fineness such that approximately 55% to 65% of the coal will pass through a 200 mesh screen and so that substantially all of the pulverized coal will pass through a 40 mesh screen, thereafter pretreating the pulverized coal by suspending the coal in the form of dust clouds in a current of slowly upwardly moving hot gases, preferably but not necessarily hot oxidizing gases, at temperatures averaging approximately 650 degrees F. or even less, to 700 degrees F., under conditions to dry the coal, to slightly reduce the hydrocarbon volatile content, to slightly lessen the density, to slightly increase the oxygen content, to eliminate the sharp edges of the coal fragments, and in general to round off the outer surface of the coal fragments. This pretreatment is followed by the separating of the treated particles from the treating gases and the showering of the pretreated coal in the form of dust clouds into and counter to a current of slowly upwardly moving hot carbonizing gases at temperatures averaging approximately 1000 degrees F., so as to produce a semi-coke product with less, slightly less, oxygen than in the original coal. The semi-coke thus produced by the direct action of hot carbonizing gases consists largely of particles in the form of relatively hollow spheroids of high porosity and low density relative to that of the original coal. Many of the spheroids have a shell-like defining structure with windows in the surface thereof. The spheroids are of such size that 5% to 20% of the semi-coke will pass through a 200 mesh screen and such that practically all will pass a 10 mesh screen. The semi-coke thus produced is in fact a low temperature coke and may have a hydrocarbon volatile content of approximately 8% to 12%.

A semi-coke produced by the direct carbonizing of raw pulverized coal in a current of slowly rising hot gases in the manner specified will possess substantially the same general characteristics as the semi-coke just described but in the instance of the direct production of the semi-coke without the pretreatment the spheroids would in general be somewhat larger than would be the case if the pretreatment were not employed. The semi-coke resulting from the two stage proc-

ess, that is the process employing the pretreating as well as the carbonizing and the same is true of the semi-coke of the single stage process, particularly if the carbonizing treatment is carried out in uniform and proper manner, will contain therein not only the spheroids just described but also spheroids which will have a structure resembling spores of the vegetable matter from which coal originated.

The semi-coke produced as above described and which is obtained as from the bottom of the retort 10 is conveyed as by suitable means 12 into a pulverizing mill or crusher 13. From this mill the crushed semi-coke or pulverized product is passed either directly or indirectly in any suitable manner to a furnace 14 wherein it is burned. The furnace illustrated is a pulverized fuel burning furnace wherein the coal is burned in suspension under conditions such that the oxygen of the air can readily combine with the pulverized product as the combustion progresses. A crushed coke or pulverized product such as obtained by the process herein outlined has a relatively large number of projecting surfaces being more or less porous and of the character to be readily attacked by the oxygen of the air thus facilitating rapid combustion and in fact relatively high temperature combustion within a localized zone if such is desired. This crushed product has a naturally increased surface area as compared with the semi-coke before crushing, moreover the crushing is such as to reduce the semi-coke into fragments of a fineness such that approximately 60% will pass a 200 mesh screen.

Applicants believe they are the first to produce a pulverized or crushed semi-coke product herein described and that they are also the first to appreciate the advantage of producing such a product and burning the same in a furnace.

What is claimed is:

1. The method of preparing coal for use in a pulverized fuel burning furnace comprising pulverizing coal, subjecting the pulverized coal to a preliminary heat treatment in an oxidizing atmosphere under conditions to drive off only a small percentage of the hydrocarbon volatile content but under conditions such that the treated coal particles lose the sharp edges and are by the preliminary heat treatment transformed from solids having sharp edges to solids having relatively smooth and rounded outer surfaces and by said preliminary heat treatment are also slightly increased in size, thereafter subjecting the treated pulverized coal to carbonization by suspending it in a gaseous medium substantially chemically inert with respect to the coal and in a carbonizing zone wherein the heat is sufficient to effect a low temperature carbonization and thereby driving off a substantial portion of the hydrocarbon volatile content of the coal and under conditions to produce semi-coke comprising in the main particles in the form of hollow spheroids, withdrawing the semi-coke and then crushing it.

2. A method of preparing coal for use in a pulverized fuel burning furnace comprising subjecting pulverized coal to the heat treating action of hot oxidizing gases at temperatures averaging approximately 650 degrees F. so as to round the surfaces of the coal particles and under conditions to only slightly reduce its hydrocarbon volatile content and to slightly lessen its density, separating the treated coal from the treating gases, subjecting the separated treated coal to carbonization at temperatures averaging approximately 1000 degrees F. while suspended in hot gases substantially chemically inert with respect to the coal so as to produce semi-coke, separating the semi-coke thus produced from the carbonizing gases and crushing the separated semi-coke.

3. A method of preparing coal for use in a pulverized fuel burning furnace comprising pulverizing the coal, preliminarily subjecting the pulverized coal to the action of hot oxidizing atmospheres at temperatures averaging approximately 650 degrees F. so as to slightly increase the oxygen content, and under conditions to slightly reduce its hydrocarbon volatile content, separating the oxidized coal from the oxidizing atmosphere, subjecting the oxidized coal to carbonization by showering it in the form of a dust cloud into and exposing it to the action of a slowly upwardly moving current of hot gases substantially chemically inert with respect to the coal at temperatures averaging approximately 1000 degrees F. so as to produce semi-coke as a residual product with slightly less oxygen than in the original coal and with a substantially less hydrocarbon volatile content than in the original coal, the treatment being such as to produce a semi-coke consisting largely of particles in the form of relatively hollow spheroids with a shell-like defining structure and of sizes such that practically all of the spheroids will pass a 10 mesh screen, separating the semi-coke thus produced from the treating gases and thereafter crushing the semi-coke.

4. A method of preparing coal for use in a pulverized fuel burning furnace comprising pulverizing coal, pretreating the pulverized coal by subjecting it to a hot oxidizing atmosphere, but without substantially reducing its hydrocarbon volatile content, separating the pretreated coal from the oxidizing atmosphere, thereafter subjecting the pretreated coal to low temperature carbonization in a hot gaseous medium which is substantially chemically inert with respect to the coal within which the coal is suspended

and by which the coal is directly heated during the carbonization so as to produce a semi-coke having an oxygen content less than the oxygen content of the original coal and with a substantially less hydrocarbon volatile content than that of the original coal, separating the semi-coke thus produced from the carbonizing gases and thereafter crushing the semi-coke.

5. A finely divided coke product obtained by showering pulverized coal in a dust-like formation into a vertical retort the average temperatures of which approximate 650 degrees F. by subjecting the coal thus showered to the pretreating action of a slowly and upwardly moving current of hot gases, by separating the coal thus pretreated, by subjecting it to carbonization by showering it in a dust-like formation down a vertical carbonizing retort wherein it is subjected to the carbonizing action of a slowly and upwardly moving current of gases which are substantially chemically inert with respect to the coal the temperatures of which gases average approximately 1000 degrees F., the carbonization being such as to produce semi-coke consisting mostly of substantially hollow spheroids with shell-like defining structures and the size of which is such that practically all of the semi-coke will pass a 10 mesh screen by separating the semi-coke thus produced from the treating and resulting gases, by collecting the semi-coke as the solid residual of the process, and by crushing the semi-coke to a fineness such that approximately 60% will pass a 200 mesh screen.

In testimony whereof, we have hereunto signed our names.

WALTER RUNGE.
EDWIN A. PACKARD.